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ADDRESS.

Delivered by the President, A. A. Common, LL.D., F.R.S., on presenting the Gold Medal to Professor E. E. Barnard.

Your Council have this year awarded the Gold Medal of the Society to Professor Edward Emerson Barnard, for his discovery of the fifth satellite of *Jupiter*, his celestial photographs and other astronomical works, and, according to custom, it becomes my pleasant duty to state more fully the circumstances that have influenced the Council in making this award.

[Before proceeding with his address the President expressed his deep regret that Professor Barnard was not present at the meeting. He had left New York on February 2 in order to be present on this occasion, but his ship, the *Trave*, had not yet arrived, and the fact that other Atlantic liners were overdue made it probable that there had been some rough weather causing the delay. As events proved, this surmise was correct, the *Trave* reaching Southampton after midnight the same night, February 12.]

The discovery of the fifth satellite of *Jupiter* (certainly the most important discovery of the last twenty years) is the product of three factors—a good telescope, a good sky, and a good observer. To the munificence of James Lick the telescope on Mount Hamilton is due, and, without detracting in the slightest degree from the credit that is due to Professor Barnard for his magnificent discovery, a large share of honour remains to James Lick and the maker of the telescope, George Alvan Clark. Without this particular combination of men it is not too much to say that the fifth satellite would yet remain to be discovered. We may congratulate our medallist on having the opportunity of using the Lick telescope, and we may certainly also congratulate the donor and the maker on having secured an observer like Professor Barnard to do justice to the telescope. Though since its discovery it has been seen by other observers in America and a few in England, yet, as was pointed out by Sir John Herschel, the difference between seeing an object already known to be there and discovering that object is very great, and, moreover, although the satellite has been seen by others, with the exception of Hermann Struve at Pulkowa, they have been unable

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to measure its position. Our knowledge of its orbit is due almost entirely to the observations of Professor Barnard himself. I do not know that I can demonstrate the magnitude of Professor Barnard's especial achievement more clearly than by calling to mind that his friend, Professor S. W. Burnham, our medallist of three years ago, had shared with him the advantages of telescope and climate for some years, and yet the satellite remained unknown.

To us the news of the discovery was announced from Mount Hamilton in the following telegram :—"Professor Holden announces that the Lick telescope has revealed the existence of a fifth satellite to *Jupiter* with a period of 12^{h} 36^{m}. Its distance from the centre of the planet is 112,400 miles, and its light compares with that of a star of the thirteenth magnitude," published on 1892 September 13 (the satellite having been discovered on September 9), which was followed by a later telegram, informing us that Professor Barnard had made the discovery, and placing the period at 17^{h} 36^{m}. The confusion that arose from these telegrams was not cleared up till about October 16, by the receipt of the *Astronomical Journal* of October 4, No. 275, in which Professor Barnard gives an interesting account of his discovery of this satellite, with the measurements he had made.

From the elongations he deduced a period of 11^{h} 49^{m}·63, but as this was only from measurements obtained between September 9 and 14, it was, of course, only a first, but, considering the extreme difficulty of the object, a very close approximation. Later observations made by Professor Barnard have enabled the period to be better determined at 11^{h} 57^{m} 22^{s}·60.

He has given a most interesting account of his discovery and a diagram showing the relative size of the satellite as compared with the other four. He estimates the diameter at about the $\frac{1}{900}$th part of the diameter of *Jupiter*, and states that a magnification which raised the other four satellites to veritable moons failed to increase the diameter of the fifth. This little body stands quite by itself in the Jovian system. In the recently published volume iv. of his *Mécanique Céleste* our late lamented Associate, M. Tisserand, remarks that the theory of its motion must be discussed quite apart from those of the other four, whose movements it is probably too small to influence seriously. Had it been larger, and our knowledge of the motions of the other four more completely worked out, it is conceivable that we might have got some suspicion of its presence from theoretical considerations, but it is noteworthy that neither in this way nor in any other was the actual discovery led up to. In the case of *Hyperion* there was a marked gap in the already complex Saturnian system which suggested the possibility of another satellite, but we had become so thoroughly accustomed to the well-established Jovian system that it must have required a positive effort to conceive the possibility of an addition to it, and

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in this way I regard the discovery of Professor Barnard as most remarkable.

I have alluded to the discovery of *Hyperion*; and, in fact, our minds, on such an occasion as the present, naturally turn to others of the same character.

Besides the fifth satellite of *Jupiter*, our century has produced six new satellites, of which four belong to those red-letter years 1846 and 1847, which added to the solar system *Neptune* and his satellite, two new satellites of *Uranus* and one (*Hyperion*) of *Saturn*. William Lassell, who had the whole credit of two of these discoveries, and a share in that of the others, received our medal in 1849 from the hands of Sir John Herschel "for the construction of his equatorial instrument and the discoveries made with it." The prominence given to the construction of the instrument bears out what I have already ventured to say above. In his presidential address, Sir John Herschel quoted an official report to the following effect:—"The simple facts are that Mr. Lassell cast his own mirror, polished it by machinery of his own contrivance, mounted it equatorially in his own fashion, and placed it in an observatory of his own engineering; that with this instrument he, a private man, of no large means, in a bad climate, discovered the satellite of *Neptune*, the eighth satellite of *Saturn*, and re-observed the satellites of *Uranus*."

Thirty years elapsed before any more new satellites were brought to our knowledge, and then Professor Asaph Hall (aided by the same constructive skill as that which enabled our present medallist to make his brilliant discovery, that of the Alvan Clarks) announced the two satellites of *Mars*. In 1879 he received our Medal for this great achievement from the hands of Lord Lindsay, now Lord Crawford. It is by the side of these men—one an Englishman, of whom we are justly proud, and the other a fellow-countryman of his own, in whom he doubtless has a similar national pride—that Professor Barnard now takes his place; and, in recognition of his right to this place, your Council has conferred upon him the highest honour in its power. Although the number of satellite discoveries credited to these three men shows a progressive decrease from four to two and from two to one (a minimum which it is, however, impossible to further reduce in the future), the quality of the achievement must on the other hand progressively rise; for it may be confidently asserted that each new discovery is harder than those preceding it. Moreover, our present medallist has other claims of an equally high character on the respect and admiration of astronomers. The terms of the formal award include his photographs and other astronomical work. But before passing to these I will venture to follow the example set by Lord Lindsay on the occasion to which I have already referred, in giving some account of the life of the man whom we hoped to have seen among us to-day. Lord Lindsay remarked that Mr. Asaph Hall's early history afforded "a bright example of what per-

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severance and determination may effect in overcoming even the most adverse circumstances," and this is equally true of our present medallist. Indeed, when we consider the life-histories of astronomers who have become famous, we cannot but be struck with their general similarity. In so many cases they have become astronomers, not through the action of outside forces, but very often in spite of them, and simply from their own determination. Professor Barnard's early life, as described* by his friend, S. W. Burnham, is like that of many other notable astronomers, but with every turn accentuated to a degree almost romantic.

He was born at Nashville, Tennessee, in 1857. His early education was limited to two months' attendance at a common school, and such instruction as his excellent mother could give him at home. Fatherless and destitute at the close of the war, he began at the age of eight or nine to work in a large photographic studio in Nashville, and soon became a faithful and accomplished assistant to his employers. The loan by a friend of Dr. Dick's book, the *Practical Astronomer*, in 1876, awakened a love for astronomy which soon grew into a passion. The use of a 1-inch cheap lens roughly mounted in a tube of his own construction showed him something of what a telescope would do; and the visit of a travelling showman to Nashville, with a small glass for street exhibition, further stimulated him to acquire as good an instrument as he could for himself. Accordingly, by practising the most rigid economy he was enabled in 1877 to purchase a 5-inch telescope, and it is significant that his first systematic work of any importance was a careful study of the planet *Jupiter*. In 1881 he began to search for new comets with his 5-inch, and discovered one on September 17 of that year. This was followed a year after by another, and in 1884 he found a comet of period 5·4 years. The next year, 1885, yielded two new comets, 1886 one, and 1887 three more; and in the five succeeding years he found altogether eleven comets, one of them (1892 V.) being another new comet of short period (6·30 years). One notable result of this success was that he several times obtained the prize of 200 dollars offered by Mr. Warner for the discovery of a new comet, and was thus enabled to buy books and other accessories and to pursue his studies with fewer financial anxieties.

In 1883 he left the photographic business, having received a Fellowship in Astronomy at the Vanderbilt University. During the preceding years he had given all his spare time to study, working in the daytime and studying alone at night. It is easy to mention these facts in a few words, but not so easy to give an idea of all that they mean—the continuous and courageous struggle against adverse circumstances of all kinds. He now utilised to the full the opportunities afforded by the University in the time he spared from the hard work at the 6-inch equa-

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* *Popular Astronomy*, and *Harper's Magazine*, September, 1893.

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torial, which resulted in the cometary discoveries above mentioned, and in many others, such as new nebulæ and double stars. To one of these last I shall refer presently.

In 1888 he was offered a position in the Lick Observatory, then about to be opened with the largest equatorial in the world, in a climate of which Professor Barnard is wont to speak with an almost reverent enthusiasm ; and the able way in which he availed himself of these advantages is now familiar matter of history. With one notable exception (that of the Sun) every description of celestial object has come under his scrutiny, and his skill as an observer is only equalled by his skill as a photographer. And after thus briefly reviewing his career, I now return to his work, and especially to his photographs, which are definitely mentioned in the terms of the award of the Medal.

The astronomical photographs which Professor Barnard has made are chiefly of comets and of the Milky Way, taken with the "Willard" lens of the Lick Observatory, having an aperture of 6 inches and a total length of 31 inches. These latter are perhaps the finest examples of star photography extant. Moreover, they are the *first photographs* made to show the structure of the Milky Way. Many observers have made eye investigations on the distribution of the stars in the Milky Way. Amongst others we may note those elaborate representations of the galaxy south of 12°·5, which became accessible in 1877 by the Atlas of the *Uranometria Argentina* of Dr. Gould and his assistants at Cordoba, followed by the elaborate map which Dr. Boeddicker prepared at Lord Rosse's observatory. These, with the drawing by Mr. Trouvelot, and the earlier drawing made by Sir John Herschel at the Cape of Good Hope, represent the attempts made to delineate the Milky Way by the pencil, and any one working at the distribution of stars in the Milky Way will naturally use these drawings for comparison.

Personally I have little doubt of the essential inferiority of the drawings to the photographs, and, though it may be of some interest to know the points of difference, I cannot but think that photographs such as those of Professor Barnard are the only safe ground in such an investigation.

With regard to the comet photographs, our medallist has the credit of having made the first discovery of a comet by photography, an event which, of course, was bound to come sooner or later, but for which full credit may freely be granted to the first in the field. The series of photographs of comets taken by Professor Barnard, showing, as they do, the rapid changes that take place in comets' tails, are of great value. He has also actually obtained meteor trails on his photographic plates. Exposing plates on 1890 August 9, 10, and 11, he got traces of the trails of meteors, and on one of the plates of Brooks' Comet, taken on 1893 November 13, there is a very fine trail of a meteor. Finally, with a small lens of short focus,

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Professor Barnard discovered the great nebula surrounding the belt of *Orion.*

We have in the library of this Society some sixty glass photographs presented by Professor Barnard, positive copies made with his own hands of some of his photographs. An inspection of these beautiful pictures, which are, I trust, well known to most of us, will reveal their merits far better than any description I can give, and I will offer but one further remark on the photographic work of our medallist. In the case of his discovery of the fifth satellite, we saw that there were at least three important factors, without any one of which success could not have been attained. But in the photography of our medallist, and in much of his other work, the external factors have less significance, and the results may be claimed almost entirely by the observer himself. Professor Barnard has shown us with what modest means good results can be obtained—with not only a small but a cheap lens, such as may be found in any magic lantern. No doubt his early experiences, of which I have spoken, were valuable in giving him this knowledge of what can be done with humble apparatus ; but we must certainly admire, not merely the skill, but the courage of a man who could, under the very shadow of the great 36-inch refractor, demonstrate the merits of a lens which could be bought for a few shillings.

Such a demonstration we might have naturally awaited from a man whose instrumental equipment was necessarily small, or who could not use a large telescope to advantage ; that it should come from Professor Barnard, who had not only the opportunity of using the great refractor, but conspicuous ability for such work, is proof not only of his untiring industry, but of his thoroughly unprejudiced mind.

To summarise the other work of our medallist is a matter of some difficulty, owing to its enormous amount and its varied character. Up to the end of last year he had published twenty-six papers in the *Monthly Notices*, eighty-five in the *Astronomische Nachrichten*, seventy-five in the *Astronomical Journal*, and seventy-four in other American papers connected with astronomy, including an important report on the eclipse of 1889 January 1, published by the Lick Observatory. These represent, in nearly every case, work done at the telescope, and show him a brilliant and untiring observer of the very first order. I shall make no attempt at completeness, but shall merely endeavour to illustrate his extraordinary keenness in observing and his versatility ; and as a first illustration, I will mention his independent discovery in 1883 of that singular phenomenon called the "Gegenschein." This was discovered many years ago by a German astronomer, though its cause is still a mystery, and even now but few astronomers, though they know what to look for, have ever seen it. That our medallist should have independently discovered it, having no knowledge of it previously, is testimony to observing skill of the highest quality ; and the fact that he himself, as I understand,

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estimates the discovery as a piece of his very best work is in itself very significant. In the same year he accomplished a unique performance in double-star astronomy. Noticing that the star *β Capricorni* disappeared at occultation by the Moon, not instantaneously, but gradually, he had sufficient confidence in his observation to ask for scrutiny of this star with the most powerful instruments available, and ultimately, with the $18\frac{1}{2}$-inch equatorial of the Dearborn Observatory at Chicago, his friend S. W. Burnham found the star to be a close and unequal double, which, as Professor Burnham himself remarked, "taxed the powers of that splendid instrument to show even to a trained eye."

To the cometary discoveries of our medallist already mentioned, it must be added that in 1889 August he discovered four satellites of Brooks' comet, and that he has followed faint comets long after they had become invisible in other instruments, notably Brooks' comet of 1889, which was observed by him nearly a year longer than by any other observer; and again, the comet discovered by himself in 1888, which he followed for over two years—the longest duration of visibility known. Such observations suggest the possibility of following some of the periodic comets all round their orbits, though it must be confessed that we are still far from the realisation of this hope.

Again, he has classified periodical comets by their visual appearance, so that on several occasions he has been able to tell a short-period comet at the first glimpse in the telescope.

In addition to the photographic discovery of new nebulæ, he has discovered many with the telescope; he has made many observations of the surfaces of the planets *Mars*, *Jupiter*, *Saturn*, and of *Jupiter's* satellites (some of which are yet unpublished), particularly the very important one of the first satellite of *Jupiter*, showing the presence of dark polar caps and a white equatorial band, an observation of the utmost delicacy and importance, particularly in the light of the anomalous appearance attributed to this satellite.

Working with the 12-inch as well as the 36-inch telescope of the Lick Observatory, he has made a series of measurements of the diameters of the major planets and of their satellites, as well as of *Mercury* and *Venus*, and the first four Asteroids and many measurements of *Saturn's* rings. His measurements of double stars are not yet all published, but they include remeasurements of many of Burnham's difficult doubles. In addition he has discovered many others, as for instance, the most delicate double star connected with the trapezium of *Orion* and *β Capricorni*, which I have already mentioned.

I trust that these instances, not exhaustive, but tolerably representative, will be sufficient to show that the claims of Professor Barnard to the honour now conferred upon him are both strong, diverse in character, and very numerous.

It would, indeed, be a thankless task to attempt a complete account of his work, for the completeness would certainly be lost

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in a very short time. Professor Barnard is in the presence of new opportunities which we all feel sure will add to his triumphs. He has left Mount Hamilton, but he has only exchanged one big telescope for another, and when the Yerkes refractor is ready, we may confidently expect news from Chicago of the kind with which he has made us familiar in the past.

The President then addressed the Foreign Secretary as follows :—Dr. Huggins :—I hope that it will not be necessary to ask you to forward this Medal to Professor Barnard, but that you will, within a very short time, be able to hand it to him. In doing so, I will ask you to express our great appreciation of his past work, and our very best wishes for his success in the future.

I have another pleasant duty to perform : to mention an award now made for the first time. This arises from a bequest by the late Mrs. Jackson-Gwilt, and consists, as the Fellows are no doubt aware, of a bronze medal and a gift of money.

Your Council have awarded this gift to Mr. Lewis Swift ; and I am sure that I need not say anything to you of Mr. Swift's astronomical labours, nor of the peculiar circumstances that will, I hope, make the gift doubly acceptable to him. In fact, as I have the opportunity of setting the precedent in this matter, I propose to refrain from giving an address ; for, though the Society has been accustomed to hear an address read in reference to the award of the Gold Medal, I think that there are reasons why the custom should not be followed in the case of this gift, and so I will only ask the Foreign Secretary to forward this medal and the gift to Mr. Swift, with the best hope of the Society that better times may come to him.